PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:

Tomokazu KOMAZAKI et al.

Application No.: New U.S. Divisional Patent Application based on U.S. Patent Application No. 09/305,304

Filed: Concurrently Herewith

Attorney Dkt. No.: 32011-169878

For: BRANCHING FILTER

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

This paper is filed concurrently with a divisional application based on co-pending application Serial Number 09/305,304 filed May 5, 1999. Attached hereto is a marked-up version of the changes made to specification and claims by the current amendment. The attached page is captioned **"Version with markings show changes made"**.

Please amend the application as follows:

IN THE SPECIFICATION:

Please replace paragraphs 1, 3 and 4, beginning at page 2, line 2, with the following rewritten paragraphs:

-- Figure 10 is a circuit structural figure of the specific circuit structure of the

branching filter shown in Figure 9. Reference number 11 is the ANT terminal, 2, 3, and 4 are branching filter circuit strip lines (inductance) (equivalent to 14 in Figure 9), 13 is the transmission filter, 15 is the receiving filter, 16 is the transmission (Tx) terminal, and 17 is the receiving (Rx) terminal.--

--Figures 11 and 12 show a portable telephone branching filter and mounting aspect, respectively. Figure 11 is a schematic perspective view of the front surface, and Figure 12 is a schematic perspective view of the back surface.--

--As is clear from the structural examples shown in Figures 11 and 12, chips 13 and 15 of the transmission and receiving filters are incorporated into on-board substrate 9. Branching filter circuit strip lines 2, 3, and 4 are provided as structural elements on this on-board substrate 9. As is also clear from Figure 12, this on-board substrate 9 comprises an insulation substrate 9a such as a resin substrate, low temperature sinter substrate, or aluminum substrate, a metallized conductive coating pattern 9b provided thereon, and an insulation pattern 9c formed by exposing substrate 9a. Branching filter circuit strip lines 2, 3, and 4 are formed in continuum with conductive coating pattern 9b.--

Please replace the section entitled "Brief Description of Drawings" with the following rewritten paragraphs:

<u>--BRIEF DESCRIPTION OF THE DRAWINGS</u>

The foregoing and other objects, features and advantages of the present invention will be better understood from the following description taken in connection with the accompanying drawings, in which;

Figure 1 is a block diagram that gives a summary explanation of a structural example of the branching filter using a SAW resonator type filter of the present invention;

Figure 2 is a circuit block diagram for explaining a specific structural example of the branching filter using a SAW resonator type filter of the present invention;

Figure 3 is a circuit block diagram for explaining another specific structural example of the branching filter using a SAW resonance type filter of the present invention;

Figure 4 (including figures 4 (A) through 4 (C)) is a schematic oblique diagram for explaining an aspect of the branching filter using a SAW resonance type filter of the present invention;

Figure 5 is a block diagram for explaining the function of each structural element of the branching filter when the transmission operation is performed for the branching filter using a SAW resonance type filter of the present invention;

Figure 6 is a block diagram for explaining the function of each structural element of the branching filter when the receive operation is performed for the branching filter using a SAW resonance type filter of the present invention;

Figure 7 is a figure that provides an explanation of the impedance of the branch filter using a SAW resonance type filter of the present invention;

Figure 8 (including figures 8 (A) and 8 (B)) is a figure that provides an explanation of the serial arm SAW resonator and its LC equivalent circuit used for the branching filter using a SAW resonance type filter of the present invention;

Figure 9 is a block diagram that gives a summary explanation of a structural

example of a conventional branching filter using a SAW resonance type filter;

Figure 10 is a figure that explains a specific structural example of a conventional branching filter using a SAW resonance type filter;

Figure 11 is a schematic perspective view seen from the front side for explaining an aspect of a conventional branching filter using a SAW resonance type filter;

Figure 12 is a schematic perspective view seen from the back side for explaining an aspect of a conventional branching filter using a SAW resonance type filter; and

Figure 13 is a schematic perspective view seen from the front side for explaining another aspect of a conventional branching filter using a SAW resonance type filter.--

Please replace paragraphs 1 and 2 beginning at page 9, line 3, with the following rewritten paragraphs:

--The branching filter 100 in the structural example shown in Figure 1 comprises an antenna terminal 102, a transmission terminal 104, and a receiving terminal 106. Also, this branching filter 100 comprises a transmission SAW filter 140 linked or connected between the antenna terminal 102 and the transmission terminal 104 and a receiving SAW filter 150 linked or connected between this antenna terminal 102 and the receiving terminal 106. This transmission SAW filter 140 and receiving SAW filter 150 have different bandpass characteristics from each other. Furthermore, the branching filter 100 comprises a composite circuit 160 made from a frequency adjusting LC circuit 108 and a branching filter circuit 110 between this antenna terminal 102 and each of the transmission SAW filter 140 and the receiving SAW filter 150. These transmission and receiving SAW filters 140 and 150, the frequency adjusting LC circuit 108, and the

branching filter circuit 110 form a branching filter circuit that uses a SAW resonator type filter.

Also, with the present invention, as will be described later with reference to Figures 2 and 3, part of this branching filter circuit 110 is constructed from a serial arm SAW resonator.--

Please replace paragraphs 2 and 3 beginning at page 10, line 14, with the following rewritten paragraphs:

--A specific example of the branching filter 100 described above will be explained with reference to Figures 2 and 3 in a case when the branching filter 100 comprises the Tx-branching filter circuit strip line 120 and Rx-branching filter circuit strip line 130. Figure 2 is a circuit diagram that shows a specific structural example of the branching filter 100 using a SAW resonator of the present invention. Figure 3 is a circuit diagram that shows another specific structural example of the branching filter 100 of the present invention.

In the structural example shown in Figure 2, the transmission SAW filter 140 is constructed as a ladder-type filter made from a two layer structure of a serial arm resonator and a parallel arm resonator. Specifically, the serial arm, connected between the Tx-branching filter circuit strip line 120 and the transmission terminal 104, comprises a first level (first) serial arm resonator (TS1) 140a from the Tx-branching filter circuit strip line 120 side and a second level (second) serial arm resonator (TS2) 140b. The parallel arm comprises a first layer (first) parallel arm resonator (TS3) 140c connected between

the first layer and second layer serial arm resonators 140a and 140b connection points and earth and a second layer (second) parallel arm resonator (TS4) 140d connected between the transmission terminal 104 and earth.--

Please replace paragraphs 2 and 3, beginning at page 11, line 8, with the following rewritten paragraphs:

--In comparison, the receiving SAW filter 150 is constructed as a ladder-type filter made from a three layer structure serial arm resonator and parallel arm resonator. Specifically, the serial arm, connected between the Rx-branching filter circuit strip line 130 and the receiving terminal 106, comprises a first layer (first) serial arm resonator (RS1) 150a from the Rx-branching filter circuit strip line 130 side, a second layer (second) serial arm resonator (RS2) 150b, and a third layer (third) serial arm resonator (RS3) 150c. The parallel arm comprises a first layer parallel arm resonator (RP1) 150d connected between the connection point of first layer and second layer serial arm resonators 150a and 150b and earth, a second layer (second) parallel arm resonator (RP2) 150e connected between the connection point of second and third serial arm resonators 150b and 150c and earth, and a third layer (third) parallel arm resonator (RP3) 150f connected between receiving terminal 106 and earth.

With the structural example shown in Figure 2, from the perspective of making the branching filter and therefore the SAW resonator filter more compact, the branching filter circuit strip lines 120 and 130 are respectively composed from the serial arm resonators (TxS and RxS) 120a and 130a.--

Please replace paragraphs 1, 2 and 3 beginning at page 12, line 1, with the following rewritten paragraph:

--In Figure 2, the frequency adjusting LC circuit 108 comprises a capacitor component 108a and an inductor component 108b which exist between the antenna terminal 102 and the branching filter circuit 110, and therefore between the Tx-branching filter circuit strip line 120 and the Rx-branching filter circuit strip line 130. The capacitance of this capacitor component 108a is C_{ANT}, and the inductance of the inductor component 108b is L_{ANT}.

With the present invention, as shown by the structural example shown in Figure 2, it is also acceptable to provide the serial arm resonators 120a and 130a for branching filter circuit strip lines described above and the transmission and receiving SAW filter first level serial arm resonators 140a and 150a individually.

However, to make the resonator filter more compact, it is also acceptable to combine these two transmission side serial arm resonators 120a and 140a to construct a single composite or combined resonator. Similarly, it is also acceptable to combine these two receiving side serial arm resonators 130a and 150a to construct a single composite or combined resonator. Figure 3 shows a structural example with these serial arm resonators 120a and 140a combined into a composite resonator 142 and serial arm resonators 130a and 150a combined into a composite resonator 152. The other structural elements shown in Figure 3 are constructed in the same manner as the structural example shown in Figure 2.--

Please replace paragraphs 1, 2 and 3 beginning at page 13, line 3, with the following rewritten paragraphs:

--Figure 4 (including Figures 4 (A) through 4(C)) is a schematic perspective view that explains a structural example seen from the perspective of an aspect of the branching filter of the present invention.

Figure 4 (A) shows an example of the transmission SAW filter 140 and the receiving SAW filter 150 formed together on one piezoelectric substrate 170. Then, this piezoelectric substrate 170 is incorporated into the package on-board substrate 180. A resin substrate, low temperature sinter substrate, or aluminum substrate can be used as this on-board substrate 180. It is also possible to use a multi-layer substrate for this on-board substrate. In this case, it is possible to provide the frequency adjusting LC circuit and branching filter circuit strip line outside the piezoelectric substrate 170, one example being on-board substrate 180. In Figure 4 (A), Tx-in and Tx-out are transmission input terminals and output terminals, and Rx-in and Rx-out are receiving input terminals and output terminals. Transmission output terminal and receiving input terminal Tx-out and Rx-in are connected to the antenna terminal 102 (Figure 1) in on-board substrate 180. On the other hand, transmission input terminal and receiving output terminal Tx-in and Rx-out correspond respectively to the transmission terminal 104 and the receiving terminal 106 shown in Figure 1.

Figure 4 (B) shows a structural example of the transmission SAW filter 140, the receiving SAW filter 150, and the branching filter circuit 110 being formed on a single common piezoelectric substrate 170. When the Tx-branching filter circuit strip line 120 and the Rx-branching filter circuit strip line 130 are contained in the branching filter

circuit strip line 110, both can be provided on this piezoelectric substrate 170. Or, when only the Tx-branching filter circuit strip line 120 is contained in the branching filter circuit strip line 110, it is acceptable to provide only this Tx-branching filter circuit strip line 120 on the piezoelectric substrate 170. Also, in Figure 4 (B), the required wiring and input terminals and output terminals are not illustrated, and the Tx-branching filter circuit strip line 120 is shown by a dotted line while the Rx-branching filter circuit strip line 130 is shown by a solid line. In this structural example, the frequency adjusting LC element 108 can be provided outside the piezoelectric substrate 170--

Please replace paragraphs 1 and 2 beginning at page 14, line 14, with the following rewritten paragraph:

--Figure 4 (C) shows a structural example in which the transmission SAW filter 140, the frequency characteristics adjusting LC element 108, the Rx-branching filter circuit strip line 130, and the receiving SAW filter 150 are all formed on a single common piezoelectric substrate 170. When the Tx-branching filter circuit strip line 120 is contained in the branching filter circuit stip line 110, this Tx-branching filter circuit strip line 120 can be provided on the piezoelectric substrate 170. Also, in this Figure 4 (C), required wiring and input terminals and output terminals are not illustrated, and this Tx-branching filter circuit strip line 120 is shown as a dotted line.

In this way, the transmission SAW filter 140 and the receiving SAW filter 150, or in some cases, the branching filter circuit 110 and/or the frequency adjusting LC element 108 are formed together on the piezoelectric substrate 170 (the piezoelectric substrate shown on any of Figures 4 (A) through 4 (C)), and this can be provided on the on-board

substrate 180.--

Please replace the paragraph beginning at page 15, line 3, with the following rewritten paragraph:

--The Tx-branching filter circuit strip line 120 and the Rx-branching filter circuit strip line 130 formed on this piezoelectric substrate 170 are each composed from a serial arm SAW resonator. Also, the structural elements provided outside the piezoelectric substrate 170 (in the structural example in Figure 4 (A), the branching filter circuit and the frequency adjusting LC element, or in the structural example in Figure 4 (B), the frequency adjusting LC element) are provided in a package that houses the on-board substrate 180. Or, though not illustrated, the package can be formed with a multi-layer structure, and the structural elements provided outside the piezoelectric substrate 170 can be provided on the intermediate layer or the upper layer (including the package lid). By using a structure like those of the structural examples shown in Figures 4 (A) through (C), it is possible to make branching filters more compact and give them a higher performance level.--

Please replace paragraphs 1, 2 and 4 beginning at page 16, line 3, with the following rewritten paragraph:

--As shown in Figure 5, when the branching filter 100 is used for transmission, transmission signals from a power amplifier 210 are sent to the transmission filter 140 via the transmission terminal 104. The frequency band of these transmission signals are restricted by the transmission filter 140, are sent to the antenna 200 via the antenna

terminal 102, and transmission signals are sent from here. In this case, the receiving system 220 that contains the Rx-branching filter circuit strip line 130 and the receiving filter 150 is viewed as a load circuit together with the antenna 200.

Also, as shown in Figure 6, when the branching filter 100 is used for receiving, signals received by the antenna 200 are sent to the receiving filter 150 via the antenna terminal 102. With the receiving filter 150, the frequency band of the received signals is restricted, and these are sent to the receiving circuit 220 via the receiving terminal 106. In this case, the transmission system 230 that includes the Tx-branching filter circuit strip line 120 and the transmission filter 140 is viewed as a load circuit together with the antenna 200.

The input impedance on the side of the Rx that includes a branching filter circuit when using the branching filter for transmission (Figure 5) is Zr. This Zr is shown as 400 in Figure 7. This Zr must satisfy the conditions of the following approximate expressions (1-1) and (1-2).--

Please replace paragraphs 1, 2, 3 and 4 beginning at page 17, line 4, with the following rewritten paragraph:

--The input impedance on the side of the Tx that includes a branching filter circuit when using the branching filter for receiving (Figure 6) is Zt. This Zt is shown as 300 in Figure 7. This Zt must satisfy the conditions of the following approximate expressions (2-1) and (2-2).

For portable telephones, the transmission band is 890 to 915 MHz and the receiving band is 935 to 960 MHz. With the transmission filter 140 in the transmission

system 230 shown in Figure 6, it is possible to set the end frequency to the receiving band of 930 to 960 MHz using the serial arm SAW resonator of this filter, so the transmission filter 140 in this case can satisfy the input impedance approximate expression (2-1). However, for the transmission system 230, it is not possible to set the end frequency of the serial arm SAW resonator of this filter to the transmission band of 890-915 MHz. Because of this, it is not possible to satisfy the input impedance approximate expressions (1-1) and (1-2).

Figure 8 (A) is a circuit diagram showing the serial arm SAW resonator used for the branching filter of the present invention, and Figure 8 (B) is an LC equivalent circuit diagram of this resonator.

Thus, to compare the impedance characteristics during transmission for a branching filter of a conventional structure (Figure 9) and those for the branching filter of the present invention(Figure 5), a simulation was performed. The branching filters used as the subject of this simulation were GSM method branching filters that use a portable telephone type SAW resonator. This GSM method branching filter does not comprise the structural elements shown by 120a and inductor 108b in Figure 2, but rather has a structure comprising the Rx-branching filter circuit strip line (for the conventional branching filter) or in place of this the serial arm SAW resonator 130a (for the branching filter of the present invention). Also, of the frequency band 890 to 960 MHz, the simulation was performed at 890, 915, 935, and 960 MHz.--

Please replace the paragraph beginning at page 18, line 11, with the following rewritten paragraph:

--The GSM method branching filter transmission filter 13 of conventional methods and transmission filter 140 of the present invention used as subjects both have the same structure as the transmission filter shown by 140 in Figure 2. Similarly, the receiving filters 15 and 150 both have the same structure as the receiving filter shown by 150 in Figure 2. Table 1 shows the intersection length (shown as D (μm) in Table 1) and electrode logarithm (shown by M in Table 1) of the SAW resonator that composes the transmission and receiving filters of these branching filters. (Please refer to the attached Table 1.) In Table 1, the SAW resonators 140a, 140b, 140c, and 140d that compose the transmission filter 140 shown in Figure 2 are shown as TS1, TS2, TS3, and TS4. Also, the serial arm SAW resonators 150a, 150b, and 150c that compose the receiving filter 150 in Figure 2 are shown as RS1, RS2, and RS3. Also, parallel arm SAW resonators 150d, 150e, and 150f are shown as RP1, RP2, and RP3. Furthermore, with the branching filter of the present invention used as a subject for simulation, the Rx-branching filter circuit strip line 130 (Figure 1) has been substituted by the serial arm SAW resonator 130a, so this serial arm SAW resonator 130a is shown as RxS. Note that the Tx-branching filter circuit strip line 120 and the serial arm SAW resonator 120a that should be substituted for this (shown as TxS in Figure 2) have been omitted.--

Please replace paragraphs 1, 2 and 3 beginning at page 19, line 6, with the following rewritten paragraphs:

--Furthermore, for the conventional branching filter (shown as 10 in Figure 9) that is the subject of simulation, the transmission filter 13 is incorporated into a single piezoelectric substrate, receiving filter 15 is incorporated into another single piezoelectric

substrate, and the Rx-branching filter circuit strip line 14 and the LC chip 12 are provided on a multi-layer substrate (on-board substrate) for which these transmission and receiving filters 13 and 15 are incorporated on the above-mentioned piezoelectric substrates.

Table 2 shows branching filter circuit impedance values for the desired parameters and obtained simulation results for the specific type of branching filter circuit. In Table 2, code items I and II indicate a branching filter of a conventional structure. Code items III, IV, and V indicate a branching filter of the present invention. (Please refer to the attached Table 2.)

In this Table 2, with the conventional branching filter I, the structure is such that the branching filter circuit is the strip line, only the Rx-branching filter circuit strip line (strip line length (LR) = 40 mm) (shown as 14 in Figure 9) is provided, without providing the Tx-branching filter circuit strip line (strip line length (LT) = 0 mm), and there is also no frequency adjusting LC chip (shown as 12 in Figure 9) provided. Therefore, the input terminal of the transmission filter 13 and the input terminal of the Rx-branching filter circuit strip line 14 are directly connected to the antenna terminal 11.--

Please replace paragraphs 1 and 2 beginning at page 20, line 3, with the following rewritten paragraphs:

--Also, with the conventional branching filter II, the structure is such that the branching filter circuit is the strip line, neither the Tx-branching filter circuit strip line nor the Rx-branching filter circuit strip line is provided (strip line length (LT, LR) = 0 mm), and there is also no frequency adjusting LC chip (shown as 12 in Figure 9) provided. Also, the input terminals of the transmission filter 13 and the receiving filter 15 are

directly connected to the antenna terminal 11.

The three types of branching filter of the present invention III, IV, and V that are subjects of simulation are not provided with a Tx-branching filter circuit strip line 120 or a serial arm SAW resonator (TxS) 120a (Figure 2) in the circuit structure shown in figure 1. Therefore, the input terminal of the transmission filter 140 is directly connected to the frequency adjusting LC element 108. Furthermore, these branching filters III, IV, and V have a structure with which instead of providing the Rx-branching filter circuit 130, the serial arm SAW resonator (RxS) 130a is provided. Then, as has already been explained in reference to Figures 2 and 3, these branching filters III, IV, and V are structured with the serial arm SAW resonator 130a, and the first level serial arm SAW resonator 150a of the receiving filter 150 combined as a composite resonator 152. Based on such conditions, the branching filter III comprises capacitor component C_{ANT} (capacitance = 10 pF) and inductor L_{ANT} (inductance = 7 nH) as the externally mounted frequency adjusting LC element 108. Also, the branching filter IV comprises not capacitor component C_{ANT} but only inductor L_{ANT} (inductance = 7 nH) as the externally mounted frequency adjusting LC element 108. Similarly, the branching filter V comprises not capacitor component C_{ANT} but only inductor L_{ANT} (inductance = 10 nH) as the externally mounted frequency adjusting LC element 108. In this way, the branching filter of the present invention is structured with the goal of improving frequency characteristics using the frequency characteristics adjusting LC element 108. Impedance values for 890, 915, 935, and 960 MHz are shown for the transmission and receiving filters of the conventional technology and the present invention.--

Please replace paragraphs 1 and 2 beginning at page 21, line 11, with the following rewritten paragraph:

--Of the conventional branching filters and that of the present invention, Table 3 shows real number and imaginary number values for input impedance Zt 300 of the transmission filter 140 and input impedance Zr 400 of the receiving filter 150 as shown in Figure 7 for specified branching filters, specifically branching filters II (conventional) and IV (the present invention) of Table 2. Then, input impedance values for 890, 900, 915, 935, and 960 MHz are shown for the transmission and receiving filters. (Please refer to the attached Table 3.)

By comparing input impedance Zt and Zr of branching filters II and IV in Table 3, it became clear that the receiving filter transmission band impedance is large for the branching filter of the present invention. Looking specifically, for the receiving filter of Table 1, when frequency f is 890 MHz, the input impedance Zr for branching filter II has a real number of 0.0127 and an imaginary number of –1.098. In comparison, the input impedance Zr for branching filter IV has a real number value of 3.54 and an imaginary number value of 23.20. In this way, the input impedance of the branching filter of the present invention is significantly larger than that of the conventional branching filter. Thus, with the branching filter of the present invention, we can see that there is a significant improvement in frequency characteristics. This improvement is also clear from the impedance characteristics results shown in Table 2.--

Please replace paragraph 2, 3, 4 and 5 beginning at page 22, line 10, with the following rewritten paragraph:

--As has already been explained, the branching filter of the present invention which was provided for the above-mentioned impedance characteristics simulation has a structure made more compact by including a receiving filter first level serial arm SAW resonator in the Rx-branching filter circuit strip line. Here, we will explain the input impedance at f = 900 MHz which is the central frequency of the transmission band which is of the most interest in terms of portable telephone quality.

When we see the transmission filter side from the point C 500 shown in Figure 7, the combined impedance Z_{IN} (Tr) is given by the following equation (3).

$$Z_{IN}(Tr) = Zt * Zr/(Zt + Zr) \qquad (3)$$

In this case, the input impedance of the transmission filter 140 and the receiving filter 150 at f = 900 MHz is as follows based on Table 3.

$$Zt(900) = 0.863 - j0.626 \qquad (4)$$

$$Zr(900) = 0.0175 - j0.934 \qquad (5)$$

Therefore, impedance Z_{IN} (Tr) (900) on the transmission filter side from the point C 500 shown in Figure 7 is given by the following equation (6).

$$Z_{IN}(Tr)(900) = 0.2409 - j0.501 \qquad (6)$$

If this Z_{IN} (Tr) (900) undergoes impedance correction only by the inductance L_{ANT} 108b of the frequency adjusting LC element 108 in the structural example shown in Figure 2 for the present invention, then the value of the inductance L_{ANT} is as follows.--

Please replace paragraphs 1, 2 and 3 beginning at page 23, line 10, with the following rewritten paragraph:

--In reality, with this type of portable telephone, the optimum characteristics are

demanded not only for frequency f = 900 MHz but for the transmission band (890 to 915 MHz). These optimum characteristics are normally determined using simulation. The branching filters IV and V shown in Table 2 show the results of adjusting impedance for transmission band 890 to 915 MHz using only the inductor L_{ANT} 108b. Also, the branching filter III shown in table 2 shows the results of adjusting impedance for the same kind of transmission band using the inductor L_{ANT} 108b and the capacitor C_{ANT} 108a. One combination of these inductor L_{ANT} and capacitor C_{ANT} values is L_{ANT} = 7.0 nH and C_{ANT} = 10.0 pF.

In this way, as is clear from the results shown in Table 2, with the structure of the branching filter of the present invention, by incorporating the transmission filter 140 and the receiving filter 150 on a single common piezoelectric substrate and by providing an externally mounted frequency adjusting LC circuit 108, it became clear that it is possible to improve frequency characteristics, particularly passband characteristics.

From the results of Table 3, it can be found that the impedance for the transmission band of the receiving filter 150 is large using the branching filter circuit strip line serial arm SAW resonator 130a. This improvement in frequency characteristics depends on the impedance seen on the filter side from the point C 500 shown in Figure 7. Specifically, it is assumed that this is caused by introducing the branching filter circuit strip line serial arm SAW resonator 130a (RxS) on the input terminal of the receiving filter 150. Inconsistencies in impedance values due to the introduction of this branching filter circuit strip line serial arm SAW resonator 130a (RxS) are adjusted with an externally mounted frequency adjusting LC element 108. This frequency adjusting LC element is made into chip form, and by providing this LC chip on the transmission and

receiving filter package on-board substrate or by providing it on a piezoelectric substrate on which is created a transmission and receiving filter, it is possible to make a branching filter comprising a SAW resonator generally more compact and higher in performance.--

IN THE ABSTRACT OF THE DISCLOSURE

Please replace the Abstract of the Disclosure at page 30, with the following rewritten paragraph:

--A branching filter comprising a SAW resonator. The branching filter comprises

a transmission SAW filter linked between an antenna terminal and a transmission terminal; a receiving SAW filter with different bandpass characteristics from the transmission SAW filter linked between the antenna terminal and the transmission terminal; a composite circuit that combines a frequency adjusting LC circuit linked between the antenna terminal and the transmission and receiving SAW filters with a branching filter circuit; and the branching filter circuit being structured to have a serial arm SAW resonator.--

IN THE CLAIMS:

Please cancel claims 1-11 without prejudice or disclaimer.

Please add the following new claims as follows:

--12. A single chip device including a plurality of surface acoustic wave filters formed on a single piezoelectric semiconductor substrate the single chip device comprising:

a transmitting SAW filter formed on the substrate the transmitting SAW filter having a first serial arm resonator and a first parallel arm resonator, the first serial arm resonator being connected to the first parallel arm resonator; and

a receiving SAW filter formed on the substrate, the receiving SAW having a second serial arm resonator and a second parallel arm resonator and a second parallel arm resonator, the second serial arm resonator being connected to the second parallel arm resonator.

13. A single chip device according to claim 12, further comprising:

a branching filter circuit formed on the substrate so as to be connected to the transmitting and receiving SAW filters.

14. A single chip device according to claim 13, wherein the branching filter circuit is composed of a third serial arm resonator.

15. A single chip device according to claim 13, further comprising:

a frequency adjusting circuit formed on the substrate so as to be connected with the branching filter circuit.

16. A single chip device according to claim 15, wherein the frequency adjusting circuit has an inductance element and a capacitance element.

17. A single chip device including a plurality of surface acoustic wave filters, the single chip device comprising:

a transmitting SAW filter having a first serial arm resonator and a first parallel arm resonator, the first serial arm resonator being connected with the first parallel arm resonator;

a receiving SAW filter having a second serial arm resonator and a second parallel arm resonator, the second serial arm resonator being connected with the second parallel arm resonator; and

a common piezoelectric substrate on which both of the transmitting SAW filter and the receiving SAW filter are formed.

18. A single chip device according to claim 17, further comprising:

a branching filter circuit being formed on the common piezoelectric substate so as to be connected with the transmitting and receiving SAW filters.

19. A single chip device according to claim 18, wherein the branching filter circuit is composed of a third serial arm resonator.

20. A single chip device according to claim 18, further comprising:

a frequency adjusting circuit being formed on the common piezoelectric substrate so as to be connected with the branching filter circuit.

21. A single chip device according to claim 20, wherein the frequency adjusting circuit has an inductance element and a capacitance element.

22. A surface acoustic wave duplexer having an antennal terminal, a transmitting terminal and a receiving terminal, comprising:

a transmitting SAW filter coupled between the antenna terminal and th transmitting terminal;

a receiving SAW filter coupled between the antenna terminal and the receiving terminal:

a common piezoelectric substrate on which both of the transmitting SAW filter and the receiving SAW filter are formed; and

a package covering the common piezoelectric substrate, wherein the antenna terminal, the transmitting terminal and the receiving terminal are formed on the package.

23. A surface acoustic wave duplexer according to claim 22, further comprising:

a branching filter circuit coupled between the antenna terminal and the transmitting SAW filter or the receiving SAW filter.

24. A surface acoustic wave duplexer according to claim 23, wherein the branching filter circuit is composed of a serial arm resonator.

25. A surface acoustic wave duplexer according to claim 23, wherein the branching filter circuit is formed on the common piezoelectric substrate with the transmitting and receiving SAW filters.

26. A surface acoustic wave duplexer according to claim 23, wherein the package has a multi-layer structure.

27. A surface acoustic wave duplexer according to claim 26, wherein the branching filter circuit is formed on the package.

28. A surface acoustic wave duplexer according to claim 26, wherein the package has a first layer substrate and a second layer substrate, the first layer substrate is disposed on the second substrate, and the branching filter circuit is formed on the first layer substrate or the second layer substrate.

29. A surface acoustic wave duplexer according to claim 23, further comprising:

a frequency adjusting circuit being coupled between the antenna terminal and the branching filter circuit.

30. A surface acoustic wave duplexer according to claim 29, wherein the frequency adjusting circuit has an inductance element and a capacitance element.

31. A surface acoustic wave duplexer according to claim 29, wherein the frequency adjusting circuit is formed on the common piezoelectric substrate together with the branching filter circuit.

32. A surface acoustic wave duplexer according to claim 29, wherein the package has a multi-layer structure.

33. A surface acoustic wave duplexer according to claim 32, wherein the frequency adjusting circuit is formed on the package.

34. A surface acoustic wave duplexer according to claim 32, wherein the package has a first layer substrate and a second layer substrate, the first layer substrate is disposed on the second substrate and the frequency adjusting circuit is formed on the first layer substrate or the second layer substrate.

35. A surface acoustic wave duplexer having an antenna terminal, a transmitting terminal and a receiving terminal, comprising:

a SAW filter chip including a transmitting SAW filter connected with the transmitting terminal and a receiving SAW filter connected with the receiving terminal, wherein both the transmitting SAW filter and the receiving SAW filter are formed on one common piezoelectric substrate;

a package covering the one common piezoelectric substrate, wherein the antenna terminal, the transmittal and the receiving terminal are formed on the package.

36. A surface acoustic wave duplexer according to claim 35, further comprising:

a branching filter circuit being coupled between the antenna terminal and the transmitting SAW filter or the receiving SAW filter.

37. A surface acoustic wave duplexer according to claim 36, wherein the branching filter circuit is composed of a serial arm resonator.

38. A surface acoustic wave duplexer according to claim 36, wherein the branching filter circuit is formed on the common piezoelectric substrate with the transmitting and receiving SAW filters.

39. A surface acoustic wave duplexer according to claim 35, wherein the package has a multi-layer structure.

40. A surface acoustic wave duplexer according to claim 39, wherein the branching filter circuit is formed on the package.

41. A surface acoustic wave duplexer according to claim 39, wherein the package has a first layer substrate and a second layer substrate, the first layer substrate being disposed on the second substrate, and the branching filter circuit is formed on the first layer substrate or the second layer substrate.

42. A surface acoustic wave duplexer according to claim 36, further comprising:

a frequency adjusting circuit being coupled between the antenna terminal and the branching filter circuit.

43. A surface acoustic wave duplexer according to claim 42, wherein the frequency adjusting circuit has an inductance element and a capacitance element.

44. A surface acoustic wave duplexer according to claim 42, wherein the frequency adjusting circuit is formed on the common piezoelectric substrate with the branching filter circuit.

45. A surface acoustic wave duplexer according to claim 42, wherein the package has a multi-layer structure.

46. A surface acoustic wave duplexer according to claim 45, wherein the frequency adjusting circuit is formed on the package.

47. A surface acoustic wave duplexer according to claim 45, wherein the package has a first layer substrate and a second layer substrate, the first layer substrate being disposed on the second substrate, and the frequency adjusting circuit is formed on the first layer substrate or the second layer substrate.--

REMARKS

By this Amendment, Claims 1-11 have been cancelled. Claims 12-47 are added.

Attached hereto is a marked-up version of the changes made to specification and claims by the current amendment. The attached page is captioned **"Version with markings show changes made"**.

Accordingly, favorable consideration of this case and early issuance of a Notice of Allowance are respectfully requested.

In the event that any further cooperation in this case is deemed to be necessary to complete its prosecution, the Examiner is respectfully urged to contact the undersigned at the telephone number listed below.

An early examination is respectfully solicited.

Respectfully submitted,

James R. Burdett
Registration No. 31,594

Venable
Post Office Box 34385
Washington, D.C. 20043-9998
Telephone: (202) 962-4800
Facsimile: (202) 962-8300

Date: **February 20, 2001**

#265323

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Please replace paragraphs 1, 3 and 4, beginning at page 2, line 2, with the following rewritten paragraphs:

-- Figure 10 is a circuit structural figure of the specific circuit structure of the branching filter shown in ~~f~~Figure 9. Reference number 11 is the ANT terminal, 2, 3, and 4 are branching filter circuit strip lines (inductance) (equivalent to 14 in Figure 9), 13 is the transmission filter, 15 is the receiving filter, 16 is the transmission (Tx) terminal, and 17 is the receiving (Rx) terminal.--

--Figures 11 and 12 show a portable telephone branching filter and mounting aspect, respectively. Figure 11 is a schematic perspective view of the front surface, and ~~f~~Figure 12 is a schematic perspective view of the back surface.--

--As is clear from the structural examples shown in ~~f~~Figures 11 and 12, chips 13 and 15 of the transmission and receiving filters are incorporated into on-board substrate 9. Branching filter circuit strip lines 2, 3, and 4 are provided as structural elements on this on-board substrate 9. As is also clear from ~~f~~Figure 12, this on-board substrate 9 comprises an insulation substrate 9a such as a resin substrate, low temperature sinter substrate, or aluminum substrate, a metallized conductive coating pattern 9b provided thereon, and an insulation pattern 9c formed by exposing substrate 9a. Branching filter circuit strip lines 2, 3, and 4 are formed in continuum with conductive coating pattern 9b.--

Please replace the section entitled "Brief Description of Drawings" with the following rewritten paragraphs:

--BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the present invention will be better understood from the following description taken in connection with the accompanying drawings, in which;

Figure 1 is a block diagram that gives a summary explanation of a structural example of the branching filter using a SAW resonator type filter of the present invention;

~~f~~Figure 2 is a circuit block diagram for explaining a specific structural example of the branching filter using a SAW resonator type filter of the present invention;

~~f~~Figure 3 is a circuit block diagram for explaining another specific structural example of the branching filter using a SAW resonance type filter of the present invention;

~~f~~Figure 4 (including figures 4 (A) through 4 (C)) is a schematic oblique diagram for explaining an aspect of the branching filter using a SAW resonance type filter of the present invention;

~~f~~Figure 5 is a block diagram for explaining the function of each structural element of the branching filter when the transmission operation is performed for the branching filter using a SAW resonance type filter of the present invention;

~~f~~Figure 6 is a block diagram for explaining the function of each structural element of the branching filter when the receive operation is performed for the branching filter

using a SAW resonance type filter of the present invention;

~~f~~Figure 7 is a figure that provides an explanation of the impedance of the branch filter using a SAW resonance type filter of the present invention;

~~f~~Figure 8 (including figures 8 (A) and 8 (B)) is a figure that provides an explanation of the serial arm SAW resonator and its LC equivalent circuit used for the branching filter using a SAW resonance type filter of the present invention;

~~f~~Figure 9 is a block diagram that gives a summary explanation of a structural example of a conventional branching filter using a SAW resonance type filter;

~~f~~Figure 10 is a figure that explains a specific structural example of a conventional branching filter using a SAW resonance type filter;

~~f~~Figure 11 is a schematic perspective view seen from the front side for explaining an aspect of a conventional branching filter using a SAW resonance type filter;

~~f~~Figure 12 is a schematic perspective view seen from the back side for explaining an aspect of a conventional branching filter using a SAW resonance type filter; and

~~f~~Figure 13 is a schematic perspective view seen from the front side for explaining another aspect of a conventional branching filter using a SAW resonance type filter.--

Please replace paragraphs 1 and 2 beginning at page 9, line 3, with the following rewritten paragraphs:

--The branching filter 100 in the structural example shown in ~~f~~Figure 1 comprises an antenna terminal 102, a transmission terminal 104, and a receiving terminal 106. Also, this branching filter 100 comprises a transmission SAW filter 140 linked or connected between the antenna terminal 102 and the transmission terminal 104 and a receiving

SAW filter 150 linked or connected between this antenna terminal 102 and the receiving terminal 106. This transmission SAW filter 140 and receiving SAW filter 150 have different bandpass characteristics from each other. Furthermore, the branching filter 100 comprises a composite circuit 160 made from a frequency adjusting LC circuit 108 and a branching filter circuit 110 between this antenna terminal 102 and each of the transmission SAW filter 140 and the receiving SAW filter 150. These transmission and receiving SAW filters 140 and 150, the frequency adjusting LC circuit 108, and the branching filter circuit 110 form a branching filter circuit that uses a SAW resonator type filter.

Also, with the present invention, as will be described later with reference to ~~f~~Figures 2 and 3, part of this branching filter circuit 110 is constructed from a serial arm SAW resonator.--

Please replace paragraphs 2 and 3 beginning at page 10, line 14, with the following rewritten paragraphs:

--A specific example of the branching filter 100 described above will be explained with reference to ~~f~~Figures 2 and 3 in a case when the branching filter 100 comprises the Tx-branching filter circuit strip line 120 and Rx-branching filter circuit strip line 130. Figure 2 is a circuit diagram that shows a specific structural example of the branching filter 100 using a SAW resonator of the present invention. Figure 3 is a circuit diagram that shows another specific structural example of the branching filter 100 of the present invention.

In the structural example shown in ~~f~~Figure 2, the transmission SAW filter 140 is constructed as a ladder-type ~~resonator~~ filter made from a two layer structure of a serial arm resonator and a parallel arm resonator. Specifically, the serial arm, connected between the Tx-branching filter circuit strip line 120 and the transmission terminal 104, comprises a first level (first) serial arm resonator (TS1) 140a from the Tx-branching filter circuit strip line 120 side and a second level (second) serial arm resonator (TS2) 140b. The parallel arm comprises a first layer (first) parallel arm resonator (TS3) 140c connected between the first layer and second layer serial arm resonators 140a and 140b connection points and earth and a second layer (second) parallel arm resonator (TS4) 140d connected between the transmission terminal 104 and earth.--

Please replace paragraphs 2 and 3, beginning at page 11, line 8, with the following rewritten paragraphs:

--In comparison, the receiving SAW filter 150 is constructed as a ladder-type ~~resonator~~ filter made from a three layer structure serial arm resonator and parallel arm resonator. Specifically, the serial arm, connected between the Rx-branching filter circuit strip line 130 and the receiving terminal 106, comprises a first layer (first) serial arm resonator (RS1) 150a from the Rx-branching filter circuit strip line 130 side, a second layer (second) serial arm resonator (RS2) 150b, and a third layer (third) serial arm resonator (RS3) 150c. The parallel arm comprises a first layer parallel arm resonator (RP1) 150d connected between the connection point of first layer and second layer serial arm resonators 150a and 150b and earth, a second layer (second) parallel arm resonator (RP2) 150e connected between the connection point of second and third serial arm

resonators 150b and 150c and earth, and a third layer (third) parallel arm resonator (RP3) 150f connected between receiving terminal 106 and earth.

With the structural example shown in ~~f~~Figure 2, from the perspective of making the branching filter and therefore the SAW resonator filter more compact, the branching filter circuit strip lines 120 and 130 are respectively composed from the serial arm resonators (TxS and RxS) 120a and 130a.--

Please replace paragraphs 1, 2 and 3 beginning at page 12, line 1, with the following rewritten paragraph:

--In ~~f~~Figure 2, the frequency adjusting LC circuit 108 comprises a capacitor component 108a and an inductor component 108b which exist between the antenna terminal 102 and the branching filter circuit 110, and therefore between the Tx-branching filter circuit strip line 120 and the Rx-branching filter circuit strip line 130. The capacitance of this capacitor component 108a is C_{ANT}, and the inductance of the inductor component 108b is L_{ANT}.

With the present invention, as shown by the structural example shown in ~~f~~Figure 2, it is also acceptable to provide the serial arm resonators 120a and 130a for branching filter circuit strip lines described above and the transmission and receiving SAW filter first level serial arm resonators 140a and 150a individually.

However, to make the resonator filter more compact, it is also acceptable to combine these two transmission side serial arm resonators 120a and 140a to construct a single composite or combined resonator. Similarly, it is also acceptable to combine these two receiving side serial arm resonators 130a and 150a to construct a single composite or

combined resonator. Figure 3 shows a structural example with these serial arm resonators 120a and 140a combined into a composite resonator 142 and serial arm resonators 130a and 150a combined into a composite resonator 152. The other structural elements shown in ~~f~~Figure 3 are constructed in the same manner as the structural example shown in ~~f~~Figure 2.--

Please replace paragraphs 1, 2 and 3 beginning at page 13, line 3, with the following rewritten paragraphs:

--Figure 4 (including ~~f~~Figures 4 (A) through 4(C)) is a schematic perspective view that explains a structural example seen from the perspective of an aspect of the branching filter of the present invention.

Figure 4 (A) shows an example of the transmission SAW filter 140 and the receiving SAW filter 150 formed together on one piezoelectric substrate 170. Then, this piezoelectric substrate 170 is incorporated into the package on-board substrate 180. A resin substrate, low temperature sinter substrate, or aluminum substrate can be used as this on-board substrate 180. It is also possible to use a multi-layer substrate for this on-board substrate. In this case, it is possible to provide the frequency adjusting LC circuit and branching filter circuit strip line outside the piezoelectric substrate 170, one example being on-board substrate 180. In ~~f~~Figure 4 (A), Tx-in and Tx-out are transmission input terminals and output terminals, and Rx-in and Rx-out are receiving input terminals and output terminals. Transmission output terminal and receiving input terminal Tx-out and Rx-in are connected to the antenna terminal 102 (~~f~~Figure 1) in on-board substrate 180. On the other hand, transmission input terminal and receiving output terminal Tx-in and

Rx-out correspond respectively to the transmission terminal 104 and the receiving terminal 106 shown in ~~f~~Figure 1.

Figure 4 (B) shows a structural example of the transmission SAW filter 140, the receiving SAW filter 150, and the branching filter circuit 110 being formed on a single common piezoelectric substrate 170. When the Tx-branching filter circuit strip line 120 and the Rx-branching filter circuit strip line 130 are contained in the branching filter circuit strip line 110, both can be provided on this piezoelectric substrate 170. Or, when only the Tx-branching filter circuit strip line 120 is contained in the branching filter circuit strip line 110, it is acceptable to provide only this Tx-branching filter circuit strip line 120 on the piezoelectric substrate 170. Also, in ~~f~~Figure 4 (B), the required wiring and input terminals and output terminals are not illustrated, and the Tx-branching filter circuit strip line 120 is shown by a dotted line while the Rx-branching filter circuit strip line 130 is shown by a solid line. In this structural example, the frequency adjusting LC element 108 can be provided outside the piezoelectric substrate 170--

Please replace paragraphs 1 and 2 beginning at page 14, line 14, with the following rewritten paragraph:

--Figure 4 (C) shows a structural example in which the transmission SAW filter 140, the frequency characteristics adjusting LC element 108, the Rx-branching filter circuit strip line 130, and the receiving SAW filter 150 are all formed on a single common piezoelectric substrate 170. When the Tx-branching filter circuit strip line 120 is contained in the branching filter circuit stip line 110, this Tx-branching filter circuit strip line 120 can be provided on the piezoelectric substrate 170. Also, in this ~~f~~Figure 4 (C),

required wiring and input terminals and output terminals are not illustrated, and this Tx-branching filter circuit strip line 120 is shown as a dotted line.

In this way, the transmission SAW filter 140 and the receiving SAW filter 150, or in some cases, the branching filter circuit 110 and/or the frequency adjusting LC element 108 are formed together on the piezoelectric substrate 170 (the piezoelectric substrate shown on any of ~~f~~Figures 4 (A) through 4 (C)), and this can be provided on the on-board substrate 180.--

Please replace the paragraph beginning at page 15, line 3, with the following rewritten paragraph:

--The Tx-branching filter circuit strip line 120 and the Rx-branching filter circuit strip line 130 formed on this piezoelectric substrate 170 are each composed from a serial arm SAW resonator. Also, the structural elements provided outside the piezoelectric substrate 170 (in the structural example in ~~f~~Figure 4 (A), the branching filter circuit and the frequency adjusting LC element, or in the structural example in ~~f~~Figure 4 (B), the frequency adjusting LC element) are provided in a package that houses the on-board substrate 180. Or, though not illustrated, the package can be formed with a multi-layer structure, and the structural elements provided outside the piezoelectric substrate 170 can be provided on the intermediate layer or the upper layer (including the package lid). By using a structure like those of the structural examples shown in ~~f~~Figures 4 (A) through (C), it is possible to make branching filters more compact and give them a higher performance level.--

Please replace paragraphs 1, 2 and 4 beginning at page 16, line 3, with the following rewritten paragraph:

--As shown in ~~f~~Figure 5, when the branching filter 100 is used for transmission, transmission signals from a power amplifier 210 are sent to the transmission filter 140 via the transmission terminal 104. The frequency band of these transmission signals are restricted by the transmission filter 140, are sent to the antenna 200 via the antenna terminal 102, and transmission signals are sent from here. In this case, the receiving system 220 that contains the Rx-branching filter circuit strip line 130 and the receiving filter 150 is viewed as a load circuit together with the antenna 200.

Also, as shown in ~~f~~Figure 6, when the branching filter 100 is used for receiving, signals received by the antenna 200 are sent to the receiving filter 150 via the antenna terminal 102. With the receiving filter 150, the frequency band of the received signals is restricted, and these are sent to the receiving circuit 220 via the receiving terminal 106. In this case, the transmission system 230 that includes the Tx-branching filter circuit strip line 120 and the transmission filter 140 is viewed as a load circuit together with the antenna 200.

The input impedance on the side of the Rx that includes a branching filter circuit when using the branching filter for transmission (~~f~~Figure 5) is Zr. This Zr is shown as 400 in ~~f~~Figure 7. This Zr must satisfy the conditions of the following approximate expressions (1-1) and (1-2).--

Please replace paragraphs 1, 2, 3 and 4 beginning at page 17, line 4, with the following rewritten paragraph:

--The input impedance on the side of the Tx that includes a branching filter circuit when using the branching filter for receiving (~~f~~Figure 6) is Zt. This Zt is shown as 300 in ~~f~~Figure 7. This Zt must satisfy the conditions of the following approximate expressions (2-1) and (2-2).

For portable telephones, the transmission band is 890 to 915 MHz and the receiving band is 935 to 960 MHz. With the transmission filter 140 in the transmission system 230 shown in ~~f~~Figure 6, it is possible to set the end frequency to the receiving band of 930 to 960 MHz using the serial arm SAW resonator of this filter, so the transmission filter 140 in this case can satisfy the input impedance approximate expression (2-1). However, for the transmission system 230, it is not possible to set the end frequency of the serial arm SAW resonator of this filter to the transmission band of 890-915 MHz. Because of this, it is not possible to satisfy the input impedance approximate expressions (1-1) and (1-2).

Figure 8 (A) is a circuit diagram showing the serial arm SAW resonator used for the branching filter of the present invention, and ~~f~~Figure 8 (B) is an LC equivalent circuit diagram of this resonator.

Thus, to compare the impedance characteristics during transmission for a branching filter of a conventional structure (~~f~~Figure 9) and those for the branching filter of the present invention(~~f~~Figure 5), a simulation was performed. The branching filters used as the subject of this simulation were GSM method branching filters that use a portable telephone type SAW resonator. This GSM method branching filter does not comprise the structural elements shown by 120a and inductor 108b in ~~f~~Figure 2, but rather has a structure comprising the Rx-branching filter circuit strip line (for the

conventional branching filter) or in place of this the serial arm SAW resonator 130a (for the branching filter of the present invention). Also, of the frequency band 890 to 960 MHz, the simulation was performed at 890, 915, 935, and 960 MHz.--

Please replace the paragraph beginning at page 18, line 11, with the following rewritten paragraph:

--The GSM method branching filter transmission filter 13 of conventional methods and transmission filter 140 of the present invention used as subjects both have the same structure as the transmission filter shown by 140 in ~~f~~Figure 2. Similarly, the receiving filters 15 and 150 both have the same structure as the receiving filter shown by 150 in ~~f~~Figure 2. Table 1 shows the intersection length (shown as D (μm) in ~~table~~Table 1) and electrode logarithm (shown by M in ~~table~~Table 1) of the SAW resonator that composes the transmission and receiving filters of these branching filters. (Please refer to the attached ~~table~~Table 1.) In ~~table~~Table 1, the SAW resonators 140a, 140b, 140c, and 140d that compose the transmission filter 140 shown in ~~f~~Figure 2 are shown as TS1, TS2, TS3, and TS4. Also, the serial arm SAW resonators 150a, 150b, and 150c that compose the receiving filter 150 in ~~f~~Figure 2 are shown as RS1, RS2, and RS3. Also, parallel arm SAW resonators 150d, 150e, and 150f are shown as RP1, RP2, and RP3. Furthermore, with the branching filter of the present invention used as a subject for simulation, the Rx-branching filter circuit strip line 130 (~~f~~Figure 1) has been substituted by the serial arm SAW resonator 130a, so this serial arm SAW resonator 130a is shown as RxS. Note that the Tx-branching filter circuit strip line 120 and the serial arm SAW resonator 120a that should be substituted for this (shown as TxS in ~~f~~Figure 2) have been omitted.--

Please replace paragraphs 1, 2 and 3 beginning at page 19, line 6, with the following rewritten paragraphs:

--Furthermore, for the conventional branching filter (shown as 10 in ~~f~~Figure 9) that is the subject of simulation, the transmission filter 13 is incorporated into a single piezoelectric substrate, receiving filter 15 is incorporated into another single piezoelectric substrate, and the Rx-branching filter circuit strip line 14 and the LC chip 12 are provided on a multi-layer substrate (on-board substrate) for which these transmission and receiving filters 13 and 15 are incorporated on the above-mentioned piezoelectric substrates.

Table 2 shows branching filter circuit impedance values for the desired parameters and obtained simulation results for the specific type of branching filter circuit. In ~~table~~Table 2, code items I and II indicate a branching filter of a conventional structure. Code items III, IV, and V indicate a branching filter of the present invention. (Please refer to the attached ~~table~~Table 2.)

In this ~~table~~Table 2, with the conventional branching filter I, the structure is such that the branching filter circuit is the strip line, only the Rx-branching filter circuit strip line (strip line length (LR) = 40 mm) (shown as 14 in ~~f~~Figure 9) is provided, without providing the Tx-branching filter circuit strip line (strip line length (LT) = 0 mm), and there is also no frequency adjusting LC chip (shown as 12 in ~~f~~Figure 9) provided. Therefore, the input terminal of the transmission filter 13 and the input terminal of the Rx-branching filter circuit strip line 14 are directly connected to the antenna terminal 11.--

Please replace paragraphs 1 and 2 beginning at page 20, line 3, with the following rewritten paragraphs:

--Also, with the conventional branching filter II, the structure is such that the branching filter circuit is the strip line, neither the Tx-branching filter circuit strip line nor the Rx-branching filter circuit strip line is provided (strip line length (LT, LR) = 0 mm), and there is also no frequency adjusting LC chip (shown as 12 in ~~f~~Figure 9) provided. Also, the input terminals of the transmission filter 13 and the receiving filter 15 are directly connected to the antenna terminal 11.

The three types of branching filter of the present invention III, IV, and V that are subjects of simulation are not provided with a Tx-branching filter circuit strip line 120 or a serial arm SAW resonator (TxS) 120a (~~f~~Figure 2) in the circuit structure shown in figure 1. Therefore, the input terminal of the transmission filter 140 is directly connected to the frequency adjusting LC element 108. Furthermore, these branching filters III, IV, and V have a structure with which instead of providing the Rx-branching filter circuit 130, the serial arm SAW resonator (RxS) 130a is provided. Then, as has already been explained in reference to ~~f~~Figures 2 and 3, these branching filters III, IV, and V are structured with the serial arm SAW resonator 130a, and the first level serial arm SAW resonator 150a of the receiving filter 150 combined as a composite resonator 152. Based on such conditions, the branching filter III comprises capacitor component C_{ANT} (capacitance = 10 pF) and inductor L_{ANT} (inductance = 7 nH) as the externally mounted frequency adjusting LC element 108. Also, the branching filter IV comprises not capacitor component C_{ANT} but only inductor L_{ANT} (inductance = 7 nH) as the externally mounted frequency adjusting LC element 108. Similarly, the branching filter V

comprises not capacitor component C_{ANT} but only inductor L_{ANT} (inductance = 10 nH) as the externally mounted frequency adjusting LC element 108. In this way, the branching filter of the present invention is structured with the goal of improving frequency characteristics using the frequency characteristics adjusting LC element 108. Impedance values for 890, 915, 935, and 960 MHz are shown for the transmission and receiving filters of the conventional technology and the present invention.--

Please replace paragraphs 1 and 2 beginning at page 21, line 11, with the following rewritten paragraph:

--Of the conventional branching filters and that of the present invention, ~~table~~Table 3 shows real number and imaginary number values for input impedance Zt 300 of the transmission filter 140 and input impedance Zr 400 of the receiving filter 150 as shown in ~~f~~Figure 7 for specified branching filters, specifically branching filters II (conventional) and IV (the present invention) of ~~table~~Table 2. Then, input impedance values for 890, 900, 915, 935, and 960 MHz are shown for the transmission and receiving filters. (Please refer to the attached ~~table~~Table 3.)

By comparing input impedance Zt and Zr of branching filters II and IV in ~~table~~Table 3, it became clear that the receiving filter transmission band impedance is large for the branching filter of the present invention. Looking specifically, for the receiving filter of ~~table~~Table 1, when frequency f is 890 MHz, the input impedance Zr for branching filter II has a real number of 0.0127 and an imaginary number of −1.098. In comparison, the input impedance Zr for branching filter IV has a real number value of 3.54 and an imaginary number value of 23.20. In this way, the input impedance of the

branching filter of the present invention is significantly larger than that of the conventional branching filter. Thus, with the branching filter of the present invention, we can see that there is a significant improvement in frequency characteristics. This improvement is also clear from the impedance characteristics results shown in ~~table~~Table 2.--

Please replace paragraph 2, 3, 4 and 5 beginning at page 22, line 10, with the following rewritten paragraph:

--As has already been explained, the branching filter of the present invention which was provided for the above-mentioned impedance characteristics simulation has a structure made more compact by including a receiving filter first level serial arm SAW resonator in the Rx-branching filter circuit strip line. Here, we will explain the input impedance at f = ~~400~~900 MHz which is the central frequency of the transmission band which is of the most interest in terms of portable telephone quality.

When we see the transmission filter side from the point C 500 shown in ~~f~~Figure 7, the combined impedance Z_{IN} (Tr) is given by the following equation (3).

$$Z_{IN}(Tr) = Zt * Zr/(Zt + Zr) \qquad (3)$$

In this case, the input impedance of the transmission filter 140 and the receiving filter 150 at f = 900 MHz is as follows based on ~~table~~ Table 3.

$$Zt(900) = 0.863 - j0.626 \qquad (4)$$

$$Zr(900) = 0.0175 - j0.934 \qquad (5)$$

Therefore, impedance Z_{IN} (Tr) (900) on the transmission filter side from the point C 500 shown in ~~f~~Figure 7 is given by the following equation (6).

Z_{IN} (Tr) (900) = 0.2409 – j0.501 (6)

If this Z_{IN} (Tr) (900) undergoes impedance correction only by the inductance L_{ANT} 108b of the frequency adjusting LC element 108 in the structural example shown in ~~f~~Figure 2 for the present invention, then the value of the inductance ~~L_{ANT} is~~L_{ANT} is as follows.--

Please replace paragraphs 1, 2 and 3 beginning at page 23, line 10, with the following rewritten paragraph:

--In reality, with this type of portable telephone, the optimum characteristics are demanded not only for frequency f = 900 MHz but for the transmission band (890 to 915 MHz). These optimum characteristics are normally determined using simulation. The branching filters IV and V shown in ~~table~~Table 2 show the results of adjusting impedance for transmission band 890 to 915 MHz using only the inductor L_{ANT} 108b. Also, the branching filter III shown in table 2 shows the results of adjusting impedance for the same kind of transmission band using the inductor L_{ANT} 108b and the capacitor C_{ANT} 108a. One combination of these inductor L_{ANT} and capacitor C_{ANT} values is L_{ANT} = 7.0 nH and C_{ANT} = 10.0 pF.

In this way, as is clear from the results shown in ~~table~~Table 2, with the structure of the branching filter of the present invention, by incorporating the transmission filter 140 and the receiving filter 150 on a single common piezoelectric substrate and by providing an externally mounted frequency adjusting LC circuit 108, it became clear that it is possible to improve frequency characteristics, particularly passband characteristics.

From the results of ~~table~~Table 3, it can be found that the impedance for the transmission band of the receiving filter 150 is large using the branching filter circuit

strip line serial arm SAW resonator 130a. This improvement in frequency characteristics depends on the impedance seen on the filter side from the point C 500 shown in ~~f~~Figure 7. Specifically, it is assumed that this is caused by introducing the branching filter circuit strip line serial arm SAW resonator 130a (RxS) on the input terminal of the receiving filter 150. Inconsistencies in impedance values due to the introduction of this branching filter circuit strip line serial arm SAW resonator 130a (RxS) are adjusted with an externally mounted frequency adjusting LC element 108. This frequency adjusting LC element is made into chip form, and by providing this LC chip on the transmission and receiving filter package on-board substrate or by providing it on a piezoelectric substrate on which is created a transmission and receiving filter, it is possible to make a branching filter comprising a SAW resonator generally more compact and higher in performance.--

IN THE ABSTRACT OF THE DISCLOSURE

Please replace the Abstract of the Disclosure at page 30, with the following rewritten paragraph:

--A branching filter comprising a SAW resonator. The ~~SAW resonator~~ branching filter comprises

a transmission SAW filter linked between an antenna terminal and a transmission terminal; a receiving SAW filter with different bandpass characteristics from the transmission SAW filter linked between the antenna terminal and the transmission terminal; a composite circuit that combines a frequency adjusting LC circuit linked between the antenna terminal and the transmission and receiving SAW filters with a branching filter circuit; and the branching filter circuit being structured to have a serial

arm SAW resonator.--